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Report on the United Nations/European Space Agency Symposium on Economic Benefits of Using Space Technology Applications in Developing Countries, Co-sponsored by the European Space Agency, the European Commission and the Government of Austria (Graz, Austria, 7-10 September 1998)

Contents

		Paragraphs	Page
I.	INTRODUCTION	1-11	2
	A. Background and objectives	1-5	2
	B. Programme	6-7	2
	C. Participants	8-11	3
II.	Observations and conclusions	12-18	3
III.	Presentations and discussions during the Symposium	19-45	4
	A. Establishing space technology applications in developing countries	22	4
	B. Economic benefits of satellite communications	23-26	5
	C. Economic benefits of Earth observation applications	27-30	5
	D. Remote sensing applications: examples	31-35	6
	E. Training and education in space technology applications	36-38	7
	F. Emerging space applications and the way forward	39-45	7

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I. Introduction

A. Background and objectives

1. The General Assembly, in its resolution 37/90 of 10 December 1982, decided that, in accordance with the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82),[1] the United Nations Programme on Space Applications should, *inter alia*, promote greater cooperation in space science and technology between developed and developing countries, as well as between developing countries.

2. The Committee on the Peaceful Uses of Outer Space at its fortieth session, held in June 1997, endorsed the programme of workshops, training courses and seminars proposed for 1998, as outlined by the Expert on Space Applications.[2] Subsequently, the General Assembly, in its resolution 52/56 of 10 December 1997, endorsed the United Nations Programme on Space Applications for 1998.

3. In response to General Assembly resolution 52/56 and in accordance with the UNISPACE 82 recommendations, the Symposium on Economic Benefits of Using Space Technology Applications in Developing Countries was jointly organized by the United Nations and the Government of Austria at Graz, Austria, from 7 to 10 September 1998. The Symposium was co-sponsored by the Federal Ministry for Foreign Affairs of Austria, the province of Styria, the city of Graz, the European Space Agency (ESA) and the European Commission. The Federal Ministry also acted as host of the Symposium, which was the sixth in a series of meetings and also served as a follow-up to the United Nations/European Space Agency Symposium on Space Industry Cooperation with the Developing World, held at Graz from 8 to 11 September 1997.

4. The main objective of the Symposium was to provide a forum for international and national space experts, policy and decision makers and representatives from space-related industry to discuss the role of space technology in securing the economic growth of developing countries. A major aim of the Symposium was to suggest possible solutions to the constraints that kept developing countries from taking full advantage of space technology applications. Participants emphasized the importance of addressing the cost-benefit aspect of using space technology and the implementation of efficient space policy plans adapted to the needs of developing countries. Such information could help to convince policy makers and other decision makers in developing countries of the value of allocating resources to implement space technology applications in support of national and regional development.

5. The present report was prepared for the forty-second session of the Committee on the Peaceful Uses of Outer Space and the thirty-sixth session of its Scientific and Technical Subcommittee. The proceedings of the Symposium, including a list of participants, will be made available in due time.

B. Programme

6. At the opening of the Symposium welcoming statements were made by representatives from the United Nations, ESA and the host country. The programme of the Symposium was divided into a series of sessions, each addressing a specific issue. Presentations by invited speakers were followed by panel discussions and brief presentations by participants from developing countries on the theme of the Symposium, describing the status of space technology applications in their respective countries. There were a total of 24 papers presented by invited speakers and 23 presentations by participants from developing countries.

7. The sessions focused on opportunities for and examples of establishing space technology applications in developing countries, the economic benefits of satellite communications and Earth observation applications, specific remote sensing application projects, training and education opportunities in space technology and space sciences and emerging space applications. In addition to the traditional space applications in the satellite telecommunications and satellite remote sensing sector, participants discussed the utilization of the international space station for benefits on Earth, the role of microgravity experiments to address health-care issues in developing countries, the use of recoverable spacecraft for agricultural plant growth experiments in China and spin-off benefits of space technologies, for example robotics originally designed for the exploration of the planet Mars, which could be used for control and monitoring tasks in decommissioned nuclear power plants.

C. Participants

8. Developing countries were invited to nominate candidates for participation in the Symposium. Participants from those countries held positions in institutions or private industry dealing with resource management, protection of the environment, communications, remote sensing systems, industrial and technological development and other fields related to the themes of the Symposium. The participants were also selected on the basis of their work experience with programmes, projects and enterprises in which space technology was already being used or was intended to be used.

9. Policy makers and others at decision-making levels from national and international entities were also invited. They were asked to highlight in their presentations the key issues relating to placing a higher priority on the operational implementation of space applications.

10. Funds allocated by the Government of Austria, ESA and the European Commission were used to cover the travel and daily expenses of participants from developing countries. In total, approximately 100 space experts attended the Symposium.

11. The following Member States were represented at the Symposium: Algeria, Austria, Azerbaijan, Benin, Brazil, Bolivia, Chile, China, Colombia, Egypt, El Salvador, Ethiopia, France, Germany, Hungary, India, Indonesia, Iran (Islamic Republic of), Kazakhstan, Kenya, Lao People's Democratic Republic, Malaysia, Mongolia, Morocco, Nepal, Nigeria, Pakistan, Philippines, Republic of Korea, Romania, Sri Lanka, Sudan, Syrian Arab Republic, Thailand, Trinidad and Tobago, United Arab Emirates, United Republic of Tanzania, United States of America, Uzbekistan, Viet Nam and Zambia. The following international organizations and national entities were represented: Office for Outer Space Affairs of the Secretariat, European Commission, ESA, International Space University (ISU); Austrian Space Agency (ASA), Brazilian Space Agency (AEB), Centre national d'études spatiales (CNES), Centre royal de télédetection spatiale (CRTS), China Aerospace Corporation (CASC), Chinese Academy of Space Technology (CAST), German Aerospace Research Establishment (DLR), Indian Space Research Organization (ISRO), Korean Aerospace Research Institute (KARI), National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL), Space and Upper Atmosphere Research Commission (SUPARCO) of Pakistan. The space industry was represented by participants from EUROCONSULT (France), Iridium Germany (Germany), Matra Marconi Space (France/United Kingdom of Great Britain and Northern Ireland), SpaceImaging EOSAT (United States), Thuraya Satellite Telecommunications Company (United Arab Emirates), and WorldSpace Inc. (United States).

II. Observations and conclusions

12. A review of the observations and conclusions made at previous Symposia showed that certain consistent issues had been raised at each meeting. While space experts in a few countries had been quite successful in gaining the political support of decision makers in implementing pre-operational and operational space technology application programmes, space experts in other countries had been less successful and had achieved little progress over the years. The main problems mentioned involved gaining access to the people in charge and finding persuasive arguments to promote the benefits resulting from the use of space technology applications. Especially in view of the many other problems faced in developing countries, it was often difficult to promote investments in space technology applications, although the economic and social benefits often far outweighed the initial investments.

13. Space application projects had resulted in both short- and long-term direct and indirect benefits. Many success stories, if made public, could serve as constructive examples for developing countries. A cost-benefit evaluation of those applications should be conducted and should be made available to relevant institutions and decision makers. Standard procedures and space application possibilities should be defined and the practical experience with the relevant systems published so that the lessons learned would also benefit other users.

14. The issue of training and education of space technology experts was also often cited as a major concern in developing countries. The trained experts often did not find benign conditions for applying their knowledge or continuing their projects once they returned to their home institutions. Institutions sending staff for training should therefore consider beforehand the post-training role and responsibilities of staff.

15. The cost of data was another major concern for developing countries. In the near future, private companies would become increasingly important as dominant players in the remote sensing data market; those companies would

have to find ways to sell their data to countries with limited funding resources for obtaining such data. It would be incumbent upon those companies to win over potential customers by clearly pointing out the economic benefits of using satellite remote sensing data.

16. Developing countries should have a central office for coordinating space activities to ensure that they benefited optimally from using space technology applications. Such an office would have to be staffed not only by administrative staff but also by space technology experts knowledgeable in the benefits of space technology applications. Ideally, the office would directly report to the key decision makers in the Government.

17. With regards to satellite telecommunications, access to regional and global satellite networks was no longer a problem for developing countries. It would now be up to each country to provide the regulatory framework for using such systems, for example, by de-monopolizing their telecommunications sectors. Such a step would enable developing countries to leapfrog into the information age.

18. Satellite service providers should continue to build awareness of the value of satellite technology and its economic and social benefits for development through studies, publications and forums. They should also establish priorities related to economic and social growth in cooperation with developing countries that use telecommunications and satellite remote sensing data. They should encourage the involvement of decision makers in order to win support for the introduction of reforms, update of policies and regulatory options.

III. Presentations and discussions during the Symposium

19. The overall theme of the Symposium was first addressed by two keynote speakers, representing the views of both the space industry of industrialized countries and of developing countries and emerging space nations.

20. Prime examples demonstrating the economic benefits of space technology were the use of satellite technology for telecommunications and Earth observation applications. Satellite technology had been an important factor in the establishment of a global information society. It was a relatively new technology that had quickly developed into a sizeable and dynamic industry and was expected to continue to grow in the foreseeable future. Satellites or, more generally, the space segment were merely the starting point in a long, value-added chain. While it might be unrealistic for many developing countries to purchase or deploy their own space segment, there were many opportunities for them as users of space technology applications to gain social and economic benefits. The rapid development and large coverage of satellites compared favourably to other alternative technologies and yielded economic advantages, especially when combined with deregulation in the telecommunications and broadcasting sector.

21. By using space technology, developing countries could skip certain phases in their development and thus quickly obtain social and economic benefits. How space technology could provide a cost-effective alternative for a country's development was demonstrated by the keynote speaker representing the Chinese Academy of Space Technology. China, with its huge population, shortage in natural resources and frequent natural disasters had recently made great strides in developing the technologies for launchers, satellite telecommunications, Earth observation and recoverable satellites to meet its needs. CASC was currently conducting a project on space technology benefits consisting of three programmes: Space Seed Breeding Satellite Programme (SSBS), Disaster Monitoring and Prevention Satellite Programme (DMPS) and a technology transfer programme to upgrade traditional industries with space technology.

A. Establishing space technology applications in developing countries

22. Within the framework of the United Nations Programme on Space Applications, the Office for Outer Space Affairs assisted developing countries with establishing and implementing space technology applications. In order to gain an understanding of the role of the United Nations/ESA symposia in contributing to the growing use of space technology applications in developing countries, participants of previous symposia were regularly contacted by the Office for Outer Space Affairs and requested to provide information on their current activities and feedback on how they had benefited from their participation. A survey conducted in 1998 resulted in responses from former participants from Bolivia, Brazil, Egypt, Indonesia, Nicaragua, Uzbekistan and Zambia, who reported on the status of various follow-up projects.

B. Economic benefits of satellite communications

23. The telecommunications market had become a driving economic force in the information age and the strong link between a solid telecommunications infrastructure and a country's economic welfare had been recognized. The telecommunications sector was currently growing at twice the rate of the global economy. Satellite systems had made significant contributions to making the global information highway a reality. The worldwide telecommunications network had resulted in the creation of an information society and had brought about major changes in the economic, social and political areas. However, the majority of the world's people still lacked access to a basic telecommunications infrastructure.

24. Developing countries could enter the information age and become part of the global village by using carefully selected space technology to immediately acquire the capabilities required for setting up a basic telecommunications infrastructure. Candidates for the development of a national information infrastructure were the use of very small aperture terminals (VSATs), high-power satellite systems using digital compression technologies to better utilize the bandwidth of the frequency spectrum for applications such as digital audio broadcast (DAB) and direct broadcasting, and satellite constellation systems for establishing a global mobile personal communication system (GMPCS). It was evident that for developing countries the economic loss of not being part of the global information highway and not utilizing the emerging space technologies would be very significant.

25. The IRIDIUM system, a constellation of more than 66 satellites deployed in low-Earth orbit (LEO), currently provided worldwide mobile telecommunications services. IRIDIUM constituted a historical breakthrough in telecommunications: the global telecommunications network could be readily accessed from any location on the planet. There was no longer a need to first establish a terrestrial telecommunications infrastructure. The IRIDIUM system was owned by an international mobile communication consortium with equity partners all over the world. The cost of using the system was relatively high, but prices were expected to decrease in the foreseeable future. Several other companies were currently deploying or developing similar satellite constellation systems.

26. The Thuraya satellite system to be established by the Thuraya Satellite Telecommunications Company based in the United Arab Emirates was a regional mobile communications system based on the use of a high-power geostationary satellite bus with huge deployable antennae to provide hand-held services. Once operational, it would serve nearly 100 countries in Asia, Africa and Europe, using a geo-synchronous satellite and hand-held, dual-mode (satellite and global system for mobile communication (GSM)) terminals. Similar satellite systems were planned to serve other regions of the world and would be able to provide comparatively low-cost services tailored to the unmet telecommunications needs of the developing world.

C. Economic benefits of Earth observation applications

27. Agriculture was a large potential market for satellite data. Satellite remote sensing could be used for crop monitoring and forecasting and estimating yields. In larger countries satellite remote sensing was the only economically feasible approach in obtaining a reliable picture of the country's crop production. Even in smaller countries, satellite remote sensing produced better data and allowed the collection of information much faster and cheaper than traditional methods. The main hurdle of remote sensing applications was that it was not easy to account for the cost of services; while tariffs existed for services in satellite telecommunications (length of transponder time used), a transparent costing structure did not yet exist for remote sensing. The economic and social benefits resulting from Earth observation applications benefited society as a whole, and it was thus necessary to provide central budget assistance.

28. Another major application would be the contribution of space-based systems for disaster prevention and mitigation. Accurate and up-to-date information before, during and after disaster events could be used to keep the loss of life and damage to property to a minimum and reduce the reaction time needed to respond to and recovery from disasters. Disaster monitoring applications were still at a pre-operational stage, mostly limited by the spatial and temporal resolution of current systems. Several new remote sensing satellite systems, including some Earth observation satellite constellations, were expected to be deployed within the next few years and should help to transform the applications into fully operational projects.

29. India was hailed as one of the most advanced countries in using remote sensing data to support sustainable

development. The country operated an indigenous, sophisticated space and ground segment, a value-added chain of government remote-sensing centres and a nation-wide infrastructure to ensure that the acquired information was integrated into the decision-making process. It's biggest success story was the active involvement of user agencies, down to the level of individual farmers.

30. The European Commission's budget for space activities within the Fourth Framework Programme (1995-1998) was 350 million European Currency Units (ECU), with most of that money earmarked for Earth observation projects. With the May 1998 launch of the SPOT 4 satellite, the first European Commission sponsored remote-sensing payload, "Vegetation", was providing daily, global information on vegetation cover from space. It's main mission was to study the continental biosphere in the context of the Kyoto Protocol. The European Commission was also involved in telecommunications and space navigation projects. Some Earth observation projects were also being conducted in cooperation with developing countries.

D. Remote sensing applications: examples

31. The traditional methods for surveying and resource mapping had been rendered obsolete through the possibilities offered by the application of space science technologies. Methods such as triangulation, trilateration and traversing had become out of date through the use of the Global Positioning System (GPS), which allowed precise positions to be determined within accuracies in the millimetre range. Currently, simple GPS receivers could be readily purchased for less than $100. GPS equipment was in wide use in developing countries, however, the capabilities of indigenous companies to service such equipment needed to be improved.

32. The management of water resources had become a major issue in many regions. Countries that mostly depended on agriculture, such as Pakistan, needed to sustain their irrigated lands to ensure the population's basic supply of food. Owing to improper management, a large amount of water was wasted and had created an alarming situation in many regions. To improve the management of water resources, it was necessary to obtain reliable and regular information on the dynamic hydrological cycle and to understand the associated processes. Remote sensing data in combination with Geographic Information Systems (GIS) offered a cost-effective solution. Although most of the work in the field was still at the research level, some operational use was being made using LANDSAT and SPOT data.

33. The increased spatial and temporal resolutions of satellite imagery and plans for deploying Earth observation satellite constellations would alleviate some of the problems faced in operationalizing remote sensing applications. The IKONOS series of satellites were expected to be deployed by the Space Imaging company by the middle of 1999 and would provide black and white images with one-metre resolution and multispectral images with four-metre resolution with a revisiting time of between one and two days. The resolution was comparable to aerial photography taken from an altitude of 3,000 metres and accurate enough to replace 1:2400 scale maps. Applications were being developed for agriculture, mapping and environmental monitoring.

34. The Committee on Earth Observation Satellites (CEOS), a creation of the G8 summit of industrialized nations, was the coordinating body for worldwide Earth observation activities. The CEOS Information Locator System (CILS) was specifically developed with the needs of developing countries in mind. CILS, which had been online since May 1997, was still in its demonstration phase. CILS servers were located in Germany (http://cils.dlr.de), at the Joint Research Centre of the European Commission in Italy (http://cils.ceo.org), at the United Nations Environment Programme (UNEP) in Nairobi, Kenya (http://cils.unep.org), at the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra, Australia (http://cils.ceo.csiro.au), and at the National Space Development Agency of Japan (NASDA) in Tokyo, Japan (http://cils.eoc.nasda.go.jp).

35. The session concluded with a panel discussion on promoting Earth observations applications in developing countries: cost-benefit considerations. Panellists discussed the benefits and obstacles of using information acquired from Earth observation applications, recognizing that remote sensing was a powerful tool in providing important information in a decision-making chain. The applications and benefits of space technology should be taught at all levels, ranging from formal education for school children to courses for decision makers. With respect to donor projects, the use of international experts should be minimized when possible, using local experts when appropriate.

E. Training and education in space technology applications

36. Developing countries had no option but to increase food production and to achieve socio-economic development to ensure a standard of living and ultimately the survival of their growing populations. Development had to be sustainable over time and could only be achieved through the use of modern technologies such as space technology, biotechnology and information technology. In developing countries, the education and training of space experts and space applications users was a major concern. A number of national, regional and international organizations were already offering a broad range of training programmes tailored to the needs of various user groups. The United Nations, under its Programme on Space Applications, was in the process of establishing several centres for space science and technology education that would provide training on a regional basis to a core group of space experts who, upon returning to their home countries, would form the basis for a well-trained team of local experts.

37. The International Space University (ISU) had been offering an interdisciplinary space studies course in the form of an annual 10-week summer session programme since 1987. Summer sessions were scheduled to be held at Suranaree University in Thailand in 1999 and in Chile in 2000. Over the last few years there had been an increase in the number of participants from emerging space nations and from developing countries. In 1996, ISU began offering an 11-month Masters of Space Studies graduate-degree programme. The topics covered the whole range of space activities, including space law, space sciences, space engineering, space life sciences, space informatics, space applications and space and society.

38. Specialized education for users of satellite remote sensing information was being offered by the International Institute for Aerospace Survey and Earth Sciences (ITC). The Institute's main objective was to assist developing countries in developing human resources to carry out aerospace surveys, use remote sensing applications, establish geoinformation systems and manage geoinformation. One field of specialization was the application of GIS and remote sensing for natural hazard mapping. Projects were being conducted on flooding in Bangladesh, on spontaneous coal combustion in China, on earthquakes in Colombia, on landslides in Colombia and Nepal and on volcanic eruptions in the Philippines.

F. Emerging space applications and the way forward

39. Space technology applications in developing countries were mostly restricted to applications in the telecommunications and Earth observation sector. The immediate benefits of those applications were obvious: establishing or improving the telecommunications infrastructure; providing up-to-date weather reports, disaster warning and mitigation measures; monitoring resources and supporting decision-making and sustainable development. However, there were a number of other, less well-known, space technology applications that could be of interest to developing countries in the near future.

40. In China, where 7 per cent of the world's arable land was used to support 22 per cent of the world's population, agriculture was the economic and social development base. The Aerospace Breeding Research Centre of CASC had flown and recovered various seeds on its recoverable spacecraft. The seedlings were exposed to the space environment for 5-15 days in an elliptic near-Earth orbit of 200-400 km, microgravity of 10^{-5} g, vacuum 10^{-5} Pa and temperature of 15-40 degrees Celsius. Genetic mutations were induced that were selectively developed after retrieval through breeding on the ground. After several generations, new strains were obtained and tested in large-scale plantation experiments. Over 100 variants of more than 50 kinds of crops had been flown in the past. The experiments resulted in the breeding of new strains with a 5 to 20 per cent increase in the yield compared to the original plants. In some instances crop quality was improved; for example, the protein content of some strains of rice increased by 9 to 12 per cent. For some strains of rice the growth period was shortened by 10 days. Low-height and disease-resistant rice seedlings as well as disease-resistant tomato and melon plants were developed. The results obtained through induced mutations in the space environment could not be reproduced by artificial irradiation or other methods on the ground. The development of space-bred seedlings with improved plant properties would directly benefit the country's large population and economy, and China planned to continue its research of aerospace breeding.

41. With the recent launch of the first components of the international space station (ISS), a new area in international space cooperation had begun to take shape. Partners in ISS, the world's largest space programme, were Belgium, Brazil, Canada, Denmark, France, Germany,

Italy, Japan, the Netherlands, Norway, the Russian Federation, Spain, Sweden, Switzerland, the United Kingdom and the United States and in the future possibly also the Ukraine. Following an ambitious schedule, the station would be built between 1998 and 2004. Although its short-term objective was to provide a laboratory for scientific and applied research, the station would ultimately help to develop procedures and technologies for space exploration beyond low Earth orbit. In the near term future, the highest priority will be given to scientific uses of ISS, including experiments in telecommunications, Earth observation applications, microgravity research (technology development, life sciences etc.) and basic space sciences.

42. Emerging space nations and developing countries would have opportunities to take part in the exploitation phase of ISS. One of the experiments on the station in which several South American universities and institutions would be participating involved research into the process of protein crystallization in the microgravity environment of space. Similar experiments had been made on several space shuttle missions. The objective would be to grow large protein crystals which, with their superior size and quality, would be better suited for structural analysis to develop a medicine against Chagas' disease. The disease was a tremendous regional health problem, affecting 16 million to 18 million people with 90 million to 100 million at risk. In combination with the systematic evaluation of hundreds of medicinal extracts acquired from plants in the rain forest, scientists might be able to develop a cure for the disease.

43. Project Pioneer was a cooperative project between the Ukraine and the United States to develop and deploy a teleoperated rover at the Chernobyl Nuclear Power Plant Unit-4 to characterize and monitor contamination levels and structural integrity, remove obstructions to enable facility access and retrieve contaminated materials for analysis. The Pioneer rover was based on NASA technologies developed for the Mars exploration programme. The rover was currently being tested and would be deployed in early 1999.

44. A presentation was made on the ongoing preparations for the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), a special session of the Committee on the Peaceful Uses of Outer Space to be held in Vienna, Austria, from 19-30 July 1999. All States Members of the United Nations, international organizations, non-governmental organizations and space-related industries had been invited to attend the Conference. UNISPACE III would cover the rapid advances made in all fields of space science and technology since the last UNISPACE conference in 1982, the opportunities for space applications to provide social and economic benefits and the increased role of the private sector. Information about UNISPACE III and its planned activities were available on the Internet (http://www.un.or.at/OOSA/).

45. The session concluded with a panel discussion on international space cooperation and means of technology transfer for space technology applications. The participants stressed the importance of education and training in all fields of space technology applications. Through the use of the World Wide Web and other Internet resources, much of the training and education could be accomplished locally without the need for sending people abroad. For example, papers, publications, training manuals as well as whole data sets were easily accessible via the Internet. Participants also commented on the role of the private sector in promoting the technology and its applications. The private sector was already a dominating factor in the case of the telecommunications sector. The entry of private ventures into the Earth observation sector might also see a more competitive remote sensing data market. Participants also stressed that countries should establish committees or commissions to plan strategies for their technology development.

Notes

[1] See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space*, Vienna, 9-21 August 1982 (A/CONF.101/10 and Corr.1 and 2), para. 430.

[2] *Official Records of the General Assembly, Fifty-second Session, Supplement No. 20* (A/52/20), para. 39.